CLAIMS

1. A supported reactive catalyst having a controlled coordination structure, comprising:

a support material;

a plurality of reactive catalyst particles disposed on the support material, the reactive catalyst particles comprising a plurality of catalytically reactive atoms including at least one member selected from the group comprising noble metals, base transition metals, rare earth metals, and solid non-metals,

the catalytically reactive atoms being arranged so that at least about 50% of a top or outer surface layer of the catalytically reactive atoms have a nearest neighbor coordination number of 2;

an anchoring material comprising at least one type of polymer, oligomer or organic compound that chemically binds at least a portion of the reactive catalyst particles to the support material, at least a portion of the anchoring material being disposed between a bottom layer of the catalytically reactive atoms and the support material.

2. A supported reactive catalyst as defined in claim 1, wherein the support material comprises a plurality of particles selected from the group comprising carbon black, graphite, silica, alumina, zeolites, metal oxides, and polymers.

3. A supported reactive catalyst as defined in claim 1, wherein the support material comprises a polymeric sheet.

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4. A supported reactive catalyst as defined in claim 1, wherein the support material comprises a membrane.

5. A supported reactive catalyst as defined in claim 1, wherein the support material is itself catalytic.

6. A supported reactive catalyst as defined in claim 5, wherein the catalytic support material comprises titanium silicate.

7. A supported reactive catalyst as defined in claim 1, wherein the support material and the anchoring material comprise corresponding functional groups that have been reacted together to form a chemical bond between the support material and the anchoring material.

8. A supported reactive catalyst as defined in claim 7, wherein the chemical bond between the support material and the anchoring material is a condensation reaction product of the corresponding functional groups of the support material and the anchoring material.

9. A supported reactive catalyst as defined in claim 8, wherein the condensation reaction product comprises at least one of an ester, ether, or amide.

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10. A supported reactive catalyst as defined in claim 1, wherein at least about 60% of a top or outer surface layer of the catalytically reactive atoms have a nearest neighbor coordination number of 2.

11. A supported reactive catalyst as defined in claim 1, wherein at least about 70% of a top or outer surface layer of the catalytically reactive atoms have a nearest neighbor coordination number of 2.

12. A supported reactive catalyst as defined in claim 1, wherein at least about 80% of a top or outer surface layer of the catalytically reactive atoms have a nearest neighbor coordination number of 2.

13. A supported reactive catalyst as defined in claim 1, wherein at least about 90% of a top or outer surface layer of the catalytically reactive atoms have a nearest neighbor coordination number of 2.

14. A supported reactive catalyst as defined in claim 1, wherein at least about 95% of a top or outer surface layer of the catalytically reactive atoms have a nearest neighbor coordination number of 2.

15. A supported reactive catalyst as defined in claim 1, wherein about 100% of a top or outer surface layer of the catalytically reactive atoms have a nearest neighbor coordination number of 2.

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16. A supported reactive catalyst as defined in claim 1, wherein the catalyst particles have a surface diameter of less than about 10 nm.

17. A supported reactive catalyst as defined in claim 1, wherein the catalyst particles have a surface diameter of less than about 6 nm.

18. A supported reactive catalyst as defined in claim 1, wherein the catalyst particles have a surface diameter of less than about 4 nm.

19. A supported reactive catalyst as defined in claim 1, wherein at least a portion of the catalytically reactive atoms comprise at least one noble metal selected from the group comprising palladium, platinum, iridium, gold, osmium, ruthenium, rhodium, and rhenium.

20. A supported reactive catalyst as defined in claim 1, wherein at least a portion of the catalytically reactive atoms comprise at least one transition metal.

21. A supported reactive catalyst as defined in claim 20, wherein the transition metal comprises at least one member selected from the group comprising chromium, manganese, iron, cobalt, nickel, copper, zirconium, tin, zinc, tungsten, titanium, molybdenum, and vanadium.

22. A supported reactive catalyst as defined in claim 1, wherein at least a portion of the catalytically reactive atoms comprise at least one rare earth metal.

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23. A supported reactive catalyst as defined in claim 1, wherein the rare earth metal comprises at least one of lanthanum or cerium.

24. A supported reactive catalyst as defined in claim 1, wherein at least a portion of the catalytically reactive atoms comprise at least one non-metal.

25. A supported reactive catalyst as defined in claim 1, wherein the catalyst particles further comprise at least one of an alkali metal or alkaline earth metal.

26. A supported reactive catalyst as defined in claim 1, wherein the anchoring agent comprises functional groups that include carbon atoms bonded to at least one electron-rich atom that is more electronegative than the carbon atoms and that is able to donate one or more electrons so as to form a bond or attraction with at least one of the catalytically reactive atoms.

27. A supported reactive catalyst as defined in claim 26, wherein the electron-rich atom comprises at least one of oxygen or nitrogen.

28. A supported reactive catalyst as defined in claim 26, wherein the electron-rich atom has a negative charge and the catalytically reactive atoms bonded to the anchoring agent have a positive charge.

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29. A supported reactive catalyst as defined in claim 1, wherein the reactive catalyst particles comprises a random distribution of at least two different types of reactive catalyst atoms.

30. A supported reactive catalyst as defined in claim 1, wherein the anchoring agent is derived from at least one control agent selected from the group comprising polacrylic acid, polyacrylic acid salts, polyvinylbenzoates, polyvinyl sulfate, polyvinyl sulfonates including sulfonated styrene, polybisphenol carbonates, polybenzimidizoles, polypyridine, sulfonated polyethylene terephthalate, polyvinyl alcohol, polyethylene glycol, and polypropylene glycol..

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31. A supported reactive catalyst having a controlled coordination structure, comprising:

a support material;

a plurality of reactive catalyst particles disposed on the support material, the reactive catalyst particles comprising a plurality of catalytically reactive atoms including at least one member selected from the group comprising base transition metals, rare earth metals, and solid non-metals,

the catalytically reactive atoms being arranged so that at least about 50% of a top or outer surface layer of the catalytically reactive atoms have a nearest neighbor coordination number of 2;

an anchoring material comprising at least one type of polymer, oligomer or organic compound that chemically binds at least a portion of the reactive catalyst particles to the support material, at least a portion of the anchoring material being disposed between a bottom layer of the catalytically reactive atoms and the support material.

32. A supported reactive catalyst as defined in claim 31, wherein at least about 70% of a top or outer surface layer of the catalytically reactive atoms have a nearest neighbor coordination number of 2.

33. A supported reactive catalyst as defined in claim 31, wherein at least about 90% of a top or outer surface layer of the catalytically reactive atoms have a nearest neighbor coordination number of 2.

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34. A supported reactive catalyst as defined in claim 31, wherein the catalyst particles have a surface diameter of less than about 10 nm.

35. A supported reactive catalyst as defined in claim 31, wherein the catalyst particles have a surface diameter of less than about 6 nm.

36. A supported reactive catalyst as defined in claim 31, wherein the reactive catalyst particles comprises a random distribution of at least two different types of reactive catalyst atoms.

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37. A method of manufacturing a supported catalyst having a controlled coordination structure, comprising:

(a) preparing an intermediate catalyst complex by reacting together:

(i) a plurality of catalyst atoms comprising at least one member selected from the group comprising noble metals, rare earth metals, base transition metals, and non-metals; and

(ii) a control agent comprising a plurality of complexing molecules selected from the group comprising polymers, oligomers, and organic compounds, wherein at least about 50% of the control agent molecules are straight-chained;

(b) contacting the intermediate catalyst complex with a support material;

(c) chemically bonding a portion of the control agent with the support material; and

(d) removing a portion of the control agent to expose a portion of the catalyst atoms, thereby yielding a supported catalyst comprising a plurality of reactive catalyst particles that (i) are chemically anchored to the support material by an anchoring agent comprising a remaining portion of the control agent and (ii) in which at least about 50% of the catalyst atoms on an upper surface of the reactive catalyst particles have a nearest neighbor coordination number of 2.

38. A method of manufacturing a supported catalyst as defined in claim 37, wherein the catalyst complex is chemically bonded to the support material by a condensation reaction.

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39. A method of manufacturing a supported catalyst as defined in claim 37, wherein (a) further comprises reacting the catalyst atoms and control agent in a liquid.

40. A method of manufacturing a supported catalyst as defined in claim 37, wherein (c) is carried out in a liquid.

41. A method of manufacturing a supported catalyst as defined in claim 40, wherein (c) yields an intermediate composition comprising said liquid and said catalyst complex chemically bonded to said support material, the method further comprising removing a substantial portion of said liquid from said intermediate composition.

42. A method of manufacturing a supported catalyst as defined in claim 37, wherein (d) comprises reducing the portion of control agent.

43. A method of manufacturing a supported catalyst as defined in claim 37, wherein (d) comprises hydrogenating the portion of the control agent.

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44. A method of manufacturing a supported catalyst as defined in claim 37, wherein (d) comprises oxidizing the portion of the control agent.

45. A method of manufacturing a supported catalyst as defined in claim 37, further comprising heat treating the supported catalyst obtained in (d) at a temperature in a range of about 50°C to about 300°C for at least about 30 minutes.

46. A method of manufacturing a supported catalyst as defined in claim 45, wherein said heat treating is carried out in an inert atomosphere.

47. A method of manufacturing a supported catalyst as defined in claim 37, wherein said heat treating is carried out at a temperature in a range of about 100°C to about 250°C for at least about 30 minutes.

48. A method of manufacturing a supported catalyst as defined in claim 37, wherein said heat treating is carried out at a temperature in a range of about 125°C to about 200°C for at least about 30 minutes.

49. A method of manufacturing a supported catalyst as defined in claim 37, wherein the reactive catalyst particles comprise a random distribution of at least two different types of reactive catalyst atoms.

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50. A method of manufacturing a supported catalyst having a controlled coordination structure, comprising:

(a) preparing an intermediate catalyst complex by reacting together:

(i) a plurality of catalyst atoms comprising at least one member selected from the group comprising rare earth metals, base transition metals, and non-metals; and

(ii) a control agent comprising a plurality of complexing molecules selected from the group comprising polymers, oligomers, and organic compounds, wherein at least about 50% of the control agent molecules are straight-chained;

(b) contacting the intermediate catalyst complex with a support material;

(c) chemically bonding a portion of the control agent with the support material; and

(d) removing a portion of the control agent to expose a portion of the catalyst atoms, thereby yielding a supported catalyst comprising a plurality of reactive catalyst particles that (i) are chemically anchored to the support material by an anchoring agent comprising a remaining portion of the control agent and (ii) in which at least about 50% of the catalyst atoms on an upper surface of the reactive catalyst particles have a nearest neighbor coordination number of 2.

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51. A method of manufacturing a supported catalyst as defined in claim 50, wherein (d) comprises oxidizing the portion of the control agent.

52. A method of manufacturing a supported catalyst as defined in claim 50, further comprising heat treating the supported catalyst obtained in (d) at a temperature in a range of about 50°C to about 300°C for at least about 30 minutes.

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53. A method of using the supported reactive catalyst of claim 1, comprising contacting one or more reactants with the supported reactive catalyst so as to yield one or more desired reaction products.

54. A method as defined in claim 53, wherein the one or more reactants comprise hydrogen and oxygen.

55. A method as defined in claim 54, wherein the one or more reaction products comprise hydrogen peroxide.

56. A method as defined in claim 55, wherein the one or more reactants further comprise at least one type of organic compound and wherein the one or more reaction products comprise at least one type of oxidized organic compound.

57. A method as defined in claim 56, wherein the hydrogen peroxide is an intermediate reaction product that reacts with the at least one type of organic compound to yield the at least one type of oxidized organic compound.

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58. A method as defined in claim 53, wherein the one or more reactants comprise oxygen and at least type of organic compound and wherein the one or more reaction products comprise at least one oxidized organic compound.

59. A method as defined in claim 53, wherein the one or more reactants comprise hydrogen and at least one type of organic compound.

60. A method as defined in claim 59, wherein the one or more reaction products comprise at least one type of hydrogenated organic compound.

61. A method as defined in claim 59, wherein the method involves at least one of hydrotreating or hydrocracking.

62. A method as defined in claim 53, wherein the one or more reactants comprise at least one type of organic compound.

63. A method as defined in claim 62, wherein the one or more reaction products comprise at least one dehydrogenated organic compound and liberated hydrogen.

64. A method as defined in claim 62, wherein the one or more reaction products comprise at least one reformed organic compound and liberated hydrogen.

65. A method as defined in claim 53, wherein the supported reactive catalyst is dispersed within a solvent.

66. A method as defined in claim 65, wherein the solvent comprises at least one liquid having a Solvent Solubility Parameter having a value in a range from about 0.14×10^{-4} to about 5×10^{-4}.

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67. A method as defined in claim 65, wherein the solvent comprises at least one liquid having a Solvent Solubility Parameter having a value in a range from about 0.2×10^{-4} to about 4×10^{-4}.

68. A method as defined in claim 65, wherein the solvent comprises at least one member selected from the group comprising oxygen containing organic compounds, alcohols, ethanol, methanol, n-propanol, isopropanol, ketones, aldehydes, furans, tetrahydrofuran, ethers, esters, nitrogen-containing organic compounds, nitriles, acetonitrile, amines, 1-propylamine, amides, dimethylformamide, phosphorus-containing organic compounds, and phosphine oxides.

69. A method as defined in claim 65, wherein the solvent comprises water.

70. A method as defined in claim 65, wherein the solvent comprises at least one member selected from the group comprising liquid hydrocarbons, aliphatic hydrocarbons, and aromatic hydrocarbons.

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